THE PROGRESSIVE FISH CULTURIST

NEWS AND VIEWS FROM MANY SOURCES ON PRACTICAL HATCHERY PROBLEMS

ISSUED BY THE

U. S. DEPARTMENT OF COMMERCE
DANIEL C. ROPER, SECRETARY

BUREAU OF FISHERIES
FRANK T. BELL, COMMISSIONER

NOVEMBER - DECEMBER 1938

WASHINGTON

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THE PROGRESSIVE FISH CULTURIST

A SERIAL memorandum published occasionally for the advancement of Federal, State and private fish culture and fishery management in fresh waters.

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BUREAU OF FISHERIES, U. S. DEPARTMENT OF COMMERCE

Memorandum I-131 Washington D. C. November-December 1938 No. 42

ICHTHYOPHTHIRIASIS IN A TROUT HATCHERY

By Louis E. Wolf

State Fish Hatchery, Rome, New York

I. INTRODUCTION

IN OCTOBER, 1937, a serious outbreak of ichthyophthiriasis occurred at the State Fish Hatchery, at Rome, New York. The fish affected were fingerling rainbow trout, and the mortality among them became very high. Ichthyophthiriasis appears to cause much more trouble in bass hatcheries, and other warm-water fish farms, than in trout hatcheries. Indeed, there is no record of a serious epidemic ever having occurred before in a New York State trout hatchery, nor has the writer been able to find any printed report of serious losses in any other American trout hatchery, though for Europe such reports have been published. Since the life history of the protozoan parasite Ichthopthirius multifiliis FOUQUET is well known, at least in a general way, and remedial measures are apparently simple and effective, no serious difficulties were expected in combatting the parasite. Some difficulties were encountered, however, and many more fish were lost than had been anticipated.

After the epidemic was over the writer undertook a critical survey of the literature on the subject. Quite a few of the statements encountered did not agree very well with his own experience, and it soon became apparent that the discrepancies were partly due to the fact that almost all writers have studied the disease on warm-water fish. Even where infected trout have been studied it has been in water considerably warmer than that found in New York State hatcheries. This temperature difference is one of the chief reasons why the trout culturist is led somewhat astray when he undertakes the generally approved measures for curing the disease.

It is thought, therefore, that the present account of an epidemic in a trout hatchery, and discussion of the literature on Ichthyophthirius from a trout culturist' point of view, might be helpful. No new remedies have been sought, and no new light is shed on the life history of the parasite. The circumstances surrounding the epidemic, and the peculiar incidence of the disease, raise questions whose solution is important to the advance of our knowledge of the health of hatchery fish.

A description of the parasite, and an account of its life history, need not be given here. It is assumed that the reader is familiar with the account given in Davis' "Care and Diseases of Trout", which publication is easily available to every fish culturist.

II. DESCRIPTION OF EPIDEMIC

The section of the hatchery in which the outbreak occurred consists of 22 ponds. The arrangemnt of these ponds is shown in Fig. 1. Note that ponds 20-22 have no connection with ponds 1-19. Series 1-3, and 7-9, and pond 22, contained rainbow fingerlings; series 16-17 contained rainbow yearlings. Series 4-6, 10-12 13-15, and 20-21 contained brown trout fingerlings; series 18-19 contained brown trout yearlings. All the diseased ponds are shaded in the diagram, those in which the disease became serious being cross-hatched.

The water supply consisted of a mixture of spring water, and water from a lake containing many species of fish. The spring water supplying ponds 20-22 was from a different source from that flowing through all the rest of the ponds, but the lake water was the same. The parasite was almost certainly brought in with the lake water.

On October 5th and 6th a few dead fish were found in pond 3. On the 7th the number increased, and upon examination these were found to be thickly infested with Ichthyophthirius. Examination of fish from ponds throughout the hatchery showed that pond 22 was also badly parasitized. Ponds 1 and 2 were lightly infected, and all the other ponds were entirely free from the parasite as far as could be determined from examining samples of fish.

The actions of the two badly infected lots were identical. In each pond a great many fish were massed in the strong current at the inlet, which was not normal behavior and did not occur in any of the other ponds. This tendency of infected fish to get into rapidly flowing water has been noted by various investigators. In the rest of the pond the fish were sluggish, hung around the edges, and could easily be caught with a dip net. There was very little darting around and rubbing against the bottom, but, as Prytherch points out, this characteristic reaction of the fish is most apparent in the early stages of infection, and in this case may have occurred before the epidemic was noticed.

The appearance of the infected fish need not be described here. For this the reader is again referred to Davis' paper. Suffice it to say that the gills of the fish, as well as the skin, were badly parasitized. Also, be it recalled, the protozoa are not on the skin, but in it, mostly beneath the epidermis.

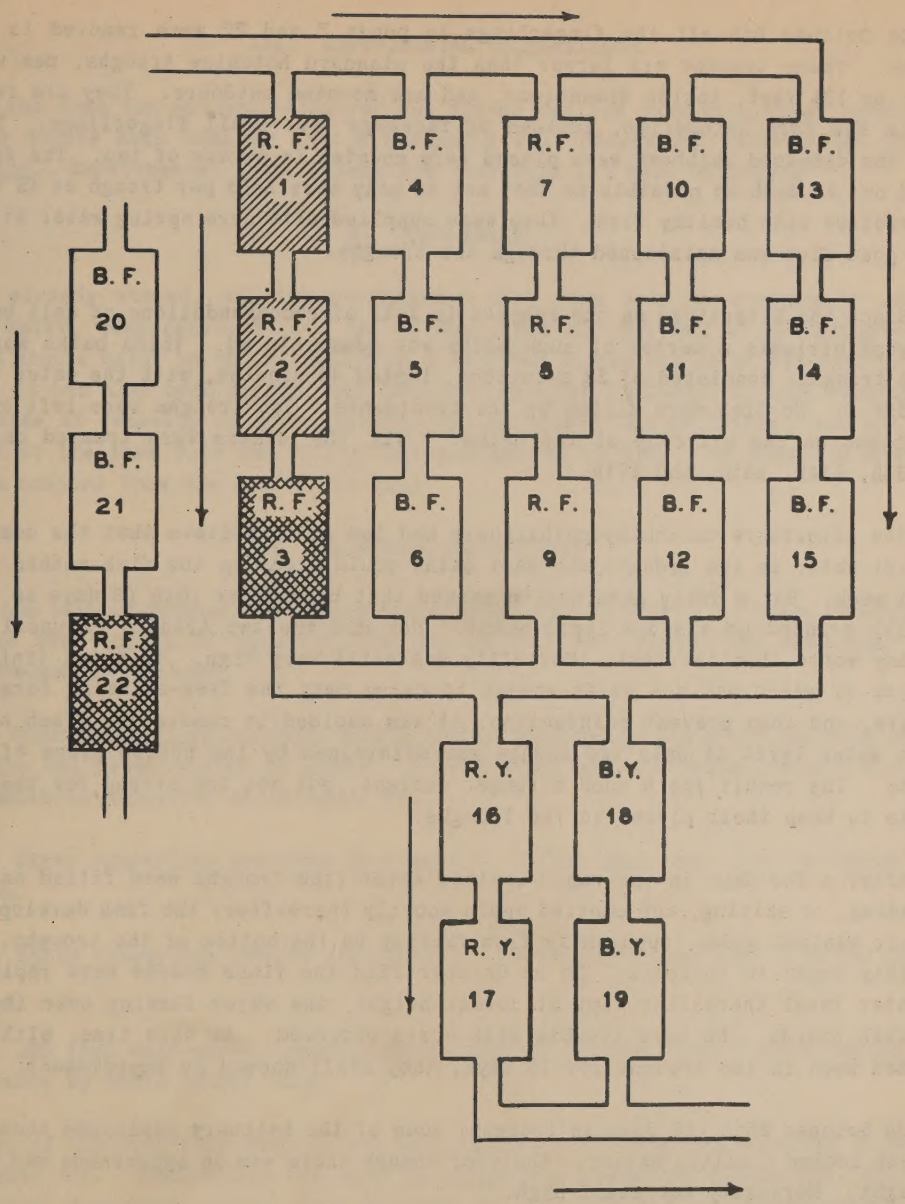

Fig. 1. ARRANGEMENT OF PONDS AND INCIDENCE OF DISEASE AT ROME HATCHERY

Diseased ponds shaded. Badly diseased cross-hatched

R. F. = RAINBOW TROUT FINGERLINGS
R. Y. = " " YEARLINGS
B. F. = BROWN TROUT FINGERLINGS
B. Y. = " " YEARLINGS

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On October 8th all the fingerlings in ponds 3 and 22 were removed to rearing troughs. These troughs are larger than the standard hatching troughs, measuring 21 inches by 13½ feet, inside dimensions, and are mounted outdoors. They are regularly used in New York hatcheries, instead of raceways for small fingerlings. Those in which the diseased rainbows were placed were mounted in series of two. The fish were spread out as much as possible so that not as many were held per trough as is our normal practice with healthy fish. They were supplied with pure spring water at 52° F., and a good flow was maintained through the troughs.

Since the literature on the subject is full of recommendations of salt baths for ichthyophthiriasis a series of such baths was administered. These baths were given in the troughs, consisted of 3% solutions, lasted 45 minutes, with the water temperature 52° F. No fish were killed by the treatments. Two troughs were left untreated as a check on the efficacy of the baths. All the others were treated on October 8th, 9th, 11th, 14th, and 17th.

The literature on ichthyophthiriasis had led us to believe that the combination of swift water in the troughs and salt baths would clear up the fish within a little over a week. But a daily examination showed that by October 16th (8 days in troughs) the fish evinced no visible improvement. Nor did the two troughs of unsalted fish look any worse than the rest. Mortality was still very high. Thinking that perhaps the flow of water was not swift enough to carry away the free-swimming forms of the parasite, and thus prevent reinfection, it was decided to remove the flash boards so that a water level of only two inches was maintained by the bottom piece of the end screens. The result was a much stronger current, but not too strong for the fish to be able to keep their places in the troughs.

After a few days in the rapid shallow water (the troughs were filled only prior to feeding, or salting, and emptied again shortly thereafter) the fish developed sores on their ventral sides, apparently from rubbing on the bottom of the troughs, and the mortality began to increase. So on October 22nd the flash boards were replaced and the water level thereafter kept at normal height, the water flowing over the top of the flash boards. No more trouble with sores occurred. At this time, although the fish had been in the troughs for 13 days, they still showed no improvement.

On October 25th (16 days in troughs) some of the hatchery employees thought that the fish looked a little better. Whatever change there was in appearance was certainly slight. Mortality was still high.

Daily examinations continued until November 4th. By that time (26 days in troughs) a noticeable improvement in appearance had taken place. Some of the fish were still very heavily infested, but many were entirely free from parasites. Mortality had dropped considerably. On that day the fish were shipped out and planted in streams, so that no further observations were possible. Thus, after 26 days in the troughs, many of the fish were still badly parasitized, though most were well on the way to recovery.

III. EXPERIMENTAL OBSERVATIONS.

At the time the epidemic occurred the writer was too busy with other investigations to devote much time to such a seemingly well understood parasite as Ichthyophthirius. Experimental observations are therefore not very extensive.

A. Salt Baths.

As already stated, all the parasitized fish were held in troughs of swiftly flowing water, temperature 52 F., for 26 days, and all but two of the troughs were given 45 minute baths in 3% salt solution five times during the first ten days of this period. It has also been pointed out that the unsalted fish went through exactly the same course of recovery as those salted, the mortality was no higher, and the fish improved at the same rate and within the same period of time. No benefits whatever could be noticed from the use of the salt.

B. Infection Experiments.

On the 14th of October 180 unparasitized fish were placed in a trough immediately below the two troughs of unsalted fish mentiond above. These 180 fish came from three sources, as follows:

(1) Sixty fingerling rainbows from a small experimental lot which had been reared in troughs and never placed in ponds. All of these had a diseased dorsel fin condition which is described below under IV C.

(2) Sixty fingerling rainbows from pond 7. These were free from the dorsal fin infection.

(3) Sixty fingerling browns from pond 6. These were also free from any infection.

All 180 fish were mixed together in the trough, groups 1 and 2 being easily distinguishable by their dorsal fins.

Some of the fish from each of the three groups were examined from day to day up to November 4th. Examination was made by means of a binocular microscope, at first only living specimens, which were replaced in the trough after examination, were used, but toward the end the specimens to be examined were killed so that their gills and mouths, as well as skin, could be studied. None ever showed any signs of the parasite.

Thus a 21 day exposure to parasites from two troughs containing several thousand heavily parasitized rainbows was not sufficient to infect the experimental fish.

IV. DISCUSSION

A. Relative Susceptibility of Rainbow and Brown Trout.

The distribution of rainbow and brown trout through the hatchery has been described, and is shown in Fig. 1. It has also been pointed out that no brown trout became infested by Ichthyophthirius. The parasite must have entered the hatchery through the lake water supply, and, that being the case, all ponds must have been equally subject to infection. Are brown trout more resistant than rainbows? Ichthyophthirius has been reported as being able to establish itself on so many unrelated fish that it would seem strange if two species within the same family should show much difference in susceptibility. Stiles collected reports of infections of rainbow trout, brown trout, brook trout, lake trout, and Atlantic salmon. Hofer (p. 122) asserts that the parasite is common on fry of rainbow, brown, and brook trout, but gives no indication of the relative susceptibility. Mellon summarized the methods used in control of Ichthyophthirius by fifteen fish culturists and investigators. Of these fifteen only four mentioned experience with trout, and of the four only two named the species of trout infected. Of these two Hayford mentioned only rainbow trout, while Guberlet named the rainbow and steelhead. This, perhaps, argues for some special susceptibility in rainbows.

But in this connection Buschkiel presents a very cogent argument when he states that the reported differences in susceptibility among species of aquarium fish can be attributed to the fact that the conditions maintained in the aquaria may be more suitable for some species than for others. Thus the species whose requirements have been met escape infection, whereas those for which the environment is not quite right are likely to catch any disease which might happen along. The apparent evidence which we have given that rainbows are perhaps more subject than other trout to ichthyophthiriasis may rather be evidence that we do not maintain in our trout hatcheries optimum conditions for this species of trout.

B. Relative Susceptibility of Fingerling And Yearling Trout.

Reference to Fig. 1 will show that ponds 16-19 were at the end of a series, and that the hundreds of thousands of spores which must have washed down from ponds 1-3 must have presented every possible opportunity for the infection of the yearling fish in those ponds. Yet all the yearlings, rainbows as well as browns, escaped the disease. Because of special circumstances surrounding all the fingerlings which took the disease (discussed in Section C, below) this cannot be regarded as clear proof that yearling rainbows are immune to ichthyophthiriasis, but that they are more resistant than fingerlings is a logcal conclusion from numerous references in the literature, not only of this particular disease but of fish diseases and parasites in general.

C. Effect of Diseased Dorsal Fins on Susceptibility Of Fingerlings

It has been pointed out that only rainbow fingerlings became parasitized; but highly significant is the fact that not all the rainbow fingerlings were involved. Those in ponds 7-9 (Fig. 1) escaped completely. There is a possible explanation for this skipping of the disease, as will be made clear in the following account of the

history of these fish prior to the epidemic.

All the rainbow fingerlings came originally from the same source, and all had been held in rearing troughs and treated alike in every respect up to July 28th. On that date ponds 7-9 were stocked, and the remaining rainbows spread out among all the troughs. It should be recalled that the rearing troughs were supplied with pure spring water, whereas the ponds received a mixture of spring and lake water.

Among the fish which were held back in the troughs an infection of the dorsal fin became noticeable on about August 20th. This infection resembled a very mild form of fin rot, as described by Davis (p. 58) - with some variations. It has appeared to some extent every year among the rainbow fingerlings at the Rome Hatchery, and always has run the same course. It is confined entirely to the dorsal fin, which becomes white and thickened. After some weeks this fin slowly disintegrates, starting at the outer edge. By early winter the dorsal fins are mostly reduced to about half size, and are still thick and white. In no case has the disintegration extended down into the dorsal musculature and produced sores about the base of the fin, although the skin for some distance around the fin sometimes becomes thickened and whitish. Never has there been any mortality attributable to this condition, and always have those fish which were held at the hatchery over winter recovered fully and regenerated their fins, so that when planted out in the spring they were normal in size and healthy in appearance. Although extensive experiments have been carried out with chemical dips and baths, none of these have proved the least bit effective in checking the condition.

The writer is informed by Dr. Davis that this condition is common among rainbow trout in many, if not most, hatcheries, and that there is much doubt as to whether it is at all related to fin rot, that is, whether it is bacterial in origin. Dr. Davis thinks not, and is of the opinion that we should not even call it a "disease." But the condition is certainly a deviation from the normal situation in a healthy fish, and in this general sense the term "disease" is applicable.

On September 10th all the trough rainbows were placed in ponds 1-3, and 22. Practically all of them showed some degree of dorsal fin disease at that time, whereas it was entirely absent in the rainbows in ponds 7-9. Was the fin disorder responsible for the fact that the fish in ponds 1-3 and 22 later contracted ichtyhphthiriasis while the rest, browns as well as rainbows, escaped? The writer is strongly of the opinion that this was the case.

Buschkiel has observed that fish which already have a bad infection, as for instance Dactylogyrus, are more susceptible to Ichthyophthirius, and that observations have shown conclusively that Ichthyophthirius preferably attacks weakened fish groups. Thus, what we had regarded as a disfiguring, but otherwise not serious disorder, in our rainbow fingerlings, may have been an important factor in the losses which we sustained through the protozoan parasite.

D. Amount of Infection in Various Ponds of a Series.

Confining our attention to the four ponds in which the disease occurred, ponds

1-3 and 22, it should be observed that it reached serious proportions only in ponds 3 and 22. In 1 and 2 it was so mild that it might never have been noticed but for the catastrophe which occurred in the other two ponds. No fish died from the disease in ponds 1 and 2, and the trout, although not even removed to troughs gradually became free of parasites.

Both of the badly infected ponds were the third in a series. It can be assumed that certain environmental conditions were worse in these than in the ones above, though to specify what these environmental factors were is not easy. The two factors which occur most readily to fish culturists are temperature and oxygen tension. But these two we can eliminate immediately. At the time the outbreak occurred (October) there was no difference in temperature in the various ponds. Although no oxygen analyses were made at the time the disease was discovered, such analysis had been made repeatedly during the preceding summer and always showed a pick-up of oxygen throughout the pond system. Thus pond 1 had the lowest dissolved oxygen content and pond 19 the highest. Surface exposure, and a slight splash of water between each two ponds, must have more than replaced the oxygen consumed by the fish. The water in ponds 3 and 22 was therefore slightly higher in dissolved oxygen than that in the ponds above, but all were considerably below the optimum for trout ponds.

That environmental conditions have a great influence upon the resistance of fish perhaps needs no special argument. It is interesting, however, that the literature of fish diseases contains very little specific data on this point. Buschkiel reports that it is a common experience with aquarium culturists that ichthyophthiriasis often breaks out when tropical fish are held too cool. Keys, in a study of the effect of parasitism on fish in the presence of other adverse environmental conditions, stated that "ectoparasites may exhibit a deleterious influence on the general vitality which becomes extremely important under adverse conditions." These adverse conditions in Keys' experiments were low oxygen tension and low salinity. Keys also quotes from Charles B. Wilson, the well known student of parasitic copepods, as follows:

"After many years of study of the ectoparasites of fishes I have come to the conclusion that as long as the fish remain healthy in other respects and are not subject to adverse conditions a reasonable number of parasites do not apparently produce harmful effects." The italics are mine.

Benish emphatically states that "On the basis of many observations it can be said that a bad attack of Costia (like ichthyophthirius, an ectoparasite) only occurs where fish have been weakened by bad living conditions."

The point the writer wishes to make from these references is that the tremendous proliferation of the parasites in ponds 3 and 22, and their deadly effect, are grounds for concluding that some unfavorable environmental factors were active in these ponds because of their position as the lower-most in a series of three.

E. Effect of Crowding on Incident of Disease.

Crowding fish to the point where it interferes with their health is, unfortunately, not an uncommon practice in hatcheries. But in this particular epidemic

crowding can hardly have been responsible for the trouble. In the following table are shown the number of pounds of fish per cubic foot of water in ponds 1-3 and 7-9 on October 1st, seven days before the disease was discovered. These figures are from the routine simple weighings made on all groups of fish at the hatchery every two weeks.

Table 1.

Number of Pounds of Fish Per Cubic Foot of Water, Oct. 1.

Pond	Lbs. Fish Per Cu. Ft. Water	Lbs. Fish Per Cu. Ft. Water Average
1	0.247	
22	0.146	0.170
3	0.117	
7	0.331	
8	0.206	0.223
9	0.153	

It will be seen that the fish were more crowded in ponds 7-9 than in 1-3. The uninfected ponds averaged considerably more pounds of fish per cubic foot of water than did the infected. And, at the risk of seeming to prove that crowding makes for resistance to disease, be it noted that ponds 1 and 2 were more crowded than 3.

F. Effect of Salt Baths.

It has already been noted that five salt baths administered during the first ten days the infected fish were held in the troughs did not hasten their recovery. No No investigator has claimed that salt solution will kill any of the parasites imbedded in the skin, but many have testified that a 3 percent solution will kill the free-swimming forms, and thus prevent formation of infective spores.

Without entering an opinion as to the exact effect of salt baths, the writer feels justified in concluding that when the flowing water treatment is given free-swimming and encysted forms are carried away. Salt baths, as usually recommended, and as administered by us, are unnecessary as a precaution against reinfection. The time and money spent on salt bath treatments in our case were wasted. For additional evidence on this point see Section I, further on in this article.

Salt baths stand in such high favor with fish culturists that it is interesting to discover in the literature a few statements which shed some doubt on the efficacy of the 3 percent bath. Thus Buschkiel asserts that he has seen brackish water fish infested with Ichthyopthirius, and that he has heard, and believes it to be a fact, that even marine fish are affected. Stiles collected a list of the reported hosts of our parasite and in it included one salt water form, the sheepshead (Archosargus

probatocephalus). The writer is not acquainted with the habits of this fish, nor has he seen the original paper in which this host was reported, so it may have come from brackish water. Stiles' list also includes the Atlantic Salmon, but this could, of course, have come from fresh water.

G. Time Necessary to Eliminate Parasite By Flowing Water Treatment

In our experience twenty-six days in rapidly flowing water was not sufficient to rid all fish of the parasite, though by the end of that time all were improved, and many completely free. It would appear therefore that at a temperature of 52 F. it requires five weeks or more for all parasites to disappear from heavily parasitized trout.

The literature contains few studies of infected fish in such cold water, and therefore most writers give a much shorter period for the length of time the parasite infests the fish. The following table presents data from various authors concerning the length of life of the parasite on the fish.

Table II.

Duration of Parasitic State of Ichthyophthirius

Author	Fish	Temperature	Duration Parasitic State on Fish.
Buschkiel	?	See next column	One to three weeks according to temp.
	Trout (badly infected)	" " "	Three weeks or longer depending on temp.
Davis	Trout	?	Several days
Plehn	?	?	About one week
Prytherch	?	65 F.	Five or six days
	?	35 -40 F.	One month or more
Roughley (1932)	?	60 -65 F.	Seven to eight days
Stiles	Catfish	Some days up to 74 F.	About a week's time
	Trout	As above (?)	Ten days
	Trout	Salt water, at above temperature ?	More than two weeks.
Wolf	Rainbow fingerlings (badly inf.)	52 F.	Four to five weeks.

H. Sterilization of Infected Ponds.

Our own observations did not shed any light on the question of the sterilization of infected ponds, as we did not contemplate restocking ponds 3 and 22 for several months. But since this question is important where the fish culturist is crowded for space it seems pertinent to include at this place a few observations on the subject culled from the literature.

Buschkiel observes that the parasites cannot live off the host longer than seventy hours, and that removing all fish from infected ponds for this length of time will, in the absence of reinfection from the water supply, eliminate the parasite.

Pearson (1932) states that "if no fish are present the spores soon die. Those observed in this laboratory lived as long as 30 hours....The parasites cannot live outside of the host's tissues longer than a few days.....(possibly) about one week."

MacLennan (1935a), says that the encysted stage may last as long as five days, and the spores are capable of infecting fish for another 96 hours. Therefore infection is possible at least eight days after the fish are removed, and two weeks are necessary to be entirely sure of starving out the parasite in an aquarium.

MacLennan (1937) has also shown that in the encysted forms the cyst wall is no protection against either drying or noxious substances. Its only demonstrated function is to affix the ciliate to the substratum.

From the statements of the three authors quoted above we can conclude that it is not necessary to treat a pond with any disinfectant, as maintained by some writers, in order to rid it of parasites. Of course, if the pond must be used again within a few days some chemical treatment will undoubtedly be necessary before restocking with healthy fish.

V. INJURY DONE TO HOST BY ICHTHYOPHTHIRIUS.

A number of heavily parasitized trout were preserved in both formalin and Bouin's fluid. All those dropped into Bouin's fluid underwent a startling change. The epidermis lifted up from the deeper layers of the skin in such a way that it could easily removed from the fish. This exposed numerous parasites, some clinging to the underside of the epidermis (Figs. 2-4) but more adhering to the exposed scales and corium. Since Bouin's fluid is one of the safest fixers, and does not ordinarily cause severe shrinkage or distortion of tissues, we must seek in the tissue itself for an explanation of the remarkable lifting up of the epidermis. The explanation is easily found in the description given by Buschkiel of the activities of the parasite on the host.

According to this author the parasite, once through the epidermis, bores passages between the epidermis and deeper layers in such a way that the former is lifted up. Occasionally one can see the formation of high "blisters" (Figs. 5-6). Once-formed

(Continued on page 14)

EXPLANATION OF FIGURES

(Opposite Page)

Figs. 2–4. Fragments of epidermis from rainbow trout, with adhering Ichthyophthirius multifiliis FOUQUET. Photographed from under (inner) side. Magnification X 128.

Fig. 2. Group of three individuals. Such groups were formerly considered evidence of reproduction while on fish. Dark area to the right of group is thickened epidermis.

Fig. 3. Single individual in midst of an area of thickened epidermis. Another protozoan probably occupied the space to the right of the specimen here shown.

Fig. 4. Single individual, whose activities have so far caused almost no thickening of the epidermis. Impression of scales on under side of epidermis quite distinct in this figure.

Figs. 5–7. Sections through skin and body wall of rainbow trout, showing position of parasites in relation to layers of skin. Magnification X 128.

Fig. 5. Single parasite within large epidermal "blister." Loosened epidermal cells are in the space surrounding the parasite.

Fig. 6. Two parasites in contact with scales.

Fig. 7. Two parasites beneath epidermis. Note separation of epidermis from deeper layers of skin at right. Such separation is responsible for the tearing off of portions of the epidermis.

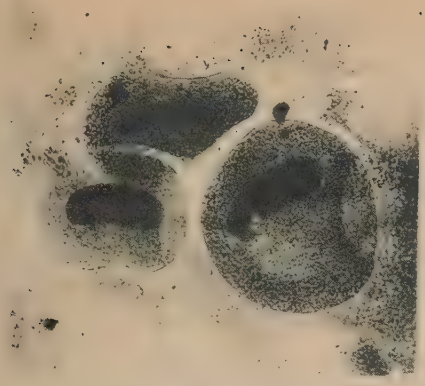

Fig. 2

Fig. 5

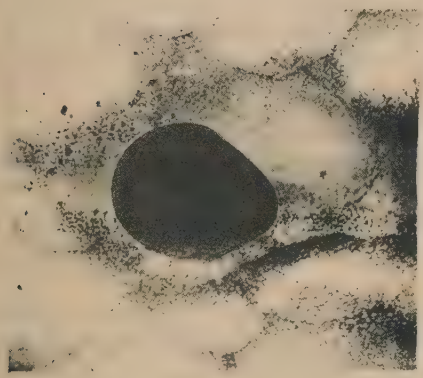

Fig. 3

Fig. 6

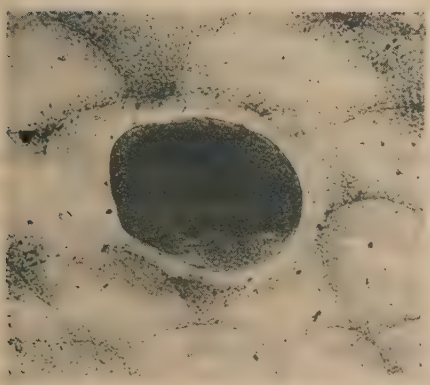

Fig. 4

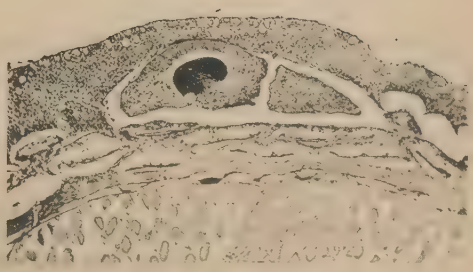

Fig. 7

entrance holes, passageways, and tunnels under the epidermis, are often used again by later entrants. Perhaps several days after reaching a position under the epidermis the parasite begins to feed. Later it settles down in one spot and finds enough to eat there, particularly as, by its constant rotation, tissue is irritated and proliferates more rapidly than normal. The parasite feeds on dislodged epithelial cells chiefly, which, according to MacLennan (1935a), "are only rarely ingested whole, but are usually broken up into small globules 5 u. in diameter which are then ingested." One young ciliate was observed by MacLennan (1935a) boring its way along beneath the epidermis at the rate of three times its body length in less than 10 minutes.

In all of the illustrations which the writer has seen of infected fish the parasite is shown imbedded in the epidermis, and entirely, or almost so, surrounded by epidermal cells. None of the illustrations referred to are of trout tissue. In my own sections of rainbow trout the parasites are almost entirely beneath, not in, the epidermis (Figs. 5-7), sometimes even partly beneath the scales. Even in the case of the largest ciliates, which project well up into the epidermis, and are to a considerable extent surrounded by it, some contacts exists with the deeper layers of the skin.

That this condition is not peculiar to trout is shown by some sections of the caudal fin of a goldfish, heavily infested with Ichthyophthirius, which the writer has in his possession. In these, as in the trout sections, all parasites are in contact with the connective tissue layer (Fig. 9).

Surrounding the parasite one often sees loosened epidermal cells (Fig. 5). These loosened cells and fragments are much more conspicious in my goldfish sections than in the trout material. It is interesting that Roth reported he was never able to find loosened epidermal cells or fragments in the space surrounding the parasites.

Reference has been made to the lifting up of the epidermis of infected fish in Bouin's fluid. This looseness of the epidermis is well shown by the space between it and the deeper layers in Figs. 6-7. Hofer states that on living fish the skin often tears loose in small, or even large, shreds. Buschkiel speaks of the lifting up of the epidermis.

Injury to the epidermis seems to be the cause of the death of heavily infected fish, and it is not at all necessary to have the further complication of fungus before heavy mortality sets in. No fungus whatever was present in our epidemic. The actual death of the fish may be due to an osmotic derangement consequent upon the epidermal injury.

Even the recent writers refer to the grayish-white spots or elevations produced in the skin by the parasite as "pimples" or "pustules." But the spots are in no sense pimples or postules since they show no inflamation and contain no pus, as was pointed out by Roth as long ago as 1898. In my sections no tissue reaction of any sort except cell proliferation by the epidermis in response to irritation from the ciliate (Figs. 3 and 7) is indicated. Mechanical injury to the epidermis seems to be the chief effect produced by the parasite.

VI. CONCLUSIONS

(1) Healthy trout can withstand attacks of ichthyophthiriasis.

(2) An ailment (in this case the dorsal fin disorder) which in itself not serious can make fish susceptible to some other more serious disease.

(3) A good environment can enable even weakened fish to resist parasitic invasion (ponds 1 and 2).

(4) A combination of weakened fish and poor environment greatly favors the increase of parasites (ponds 3 and 22).

(5) The temperature and the dissolved oxygen content of the water are not sufficient indicators of conditions in a trout pond.

(6) Salt baths do not aid in the treatment of ichthyophthiriasis by the flowing water method.

(7) At a temperature of 52 F. it takes from four to five weeks to rid heavily infected trout of all Ichthyophthirius parasites by the rapid flowing water method.

(8) In a trough supplied by a good current of cold water trout will not become infected with ichthyophthiriasis.

(9) It is not necessary to sterilize infected ponds chemically before restocking with healthy fish, provided the ponds can be held free of fish for two weeks. (This conclusion is based entirely on the literature.)

(10) Ichthyophthirius injures its host through mechanical damage done to the epidermis.

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MARYLAND SMALL MOUTH BASS SPAWN WHEN SIXTEEN MONTHS OLD IN SOUTH AFRICA

By A. Cecil Harrison, Inland Fisheries Advisory Officer,
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ONLY TWELVE MONTHS AGO in No. 33 of the PROGRESSIVE FISH CULTURIST our good friend Mr. A. M. Powell, Superintendent of Fish Hatcheries, Maryland Conservation Department, gave an account of the methods he had used to send "the greatest sport fish that swims" alive to South Africa during October 1937. It seems like a miracle but it is a real fact that today we have thousands of small mouth bass fry here bred from a mere bag limit of Maryland stock. And the Maryland smallmouth stock was only hatched between the dates May 4 and 14, 1937.

Perhaps a few details of the October 1937 shipment should be given which were not available to Mr. Powell when he wrote in the November 1937 issue.

The smallmouth fingerlings did the voyage on the M. V. "City of New York" from New York to Capetown entirely without food, but more than half came through alive. Actually there were 28 survivors, not 26 as I radiod Mr. Powell. I must have missed one dip of the net under the stress of getting the fish safely out of the shipping tanks on the fore-hatch cover of the vessel - with cargo slings working and the freight workers jostling.

The bass left New York on October 1, and as they were near the end of their normal growing season no doubt they would not have suffered much from three weeks starvation in cold water. But the following figures from the records of Mr. A. M. Vida, who looked after them so well, will give some idea of what they had to endure across the tropical ocean:

DATE. OCTOBER	1	2	3	4	5	6	7	8	9	10	11	12
WATER TEMP. FAHR.	58	60	74	75	75	78	78	80	81	83	79	79
BASS DEAD	0	0	4	5	5	6	1	2	1	0	0	2

DATE. OCTOBER	13	14	15	16	17	18	19	20	21	22
WATER TEMP. FAHR.	76	76	76	70	68	64	64	61	60	61
BASS DEAD.	0	0	0	0	0	0	0	0	0	0

The exposed position of the shipping tanks on the fore-hatch cover, right up in the bow of the vessel, cut both ways. The tanks were liable to be soaked outside with sea spray and to have protecting tarpaulins blown to shreds in a gale. The electric motors and air pumps were liable to sea damage. On the other hand, the tanks got a stream of air from the movement of the ship on the deadest day and they were always under the eye of someone in authority on the navigation bridge. Actually, in spite of some very heavy splashing and spraying, Mr. Powell's tanks were so well protected that samples of the water taken for salinity test at Capetown showed that nothing much more than sea air could have got in. Fortunately Mr. Vida is expert with electric gear, and when trouble occurred from sea damage he switched from one unit to the other and kept the vital air going during the bad period.

When the ship came into dock at Capetown from a cool breeze outside the water in the tanks was cooler than that at the Jonkershoek Hatchery, but we had brought ours down to 61 deg. in the export fruit pre-cooling plant at the docks, as it was a very hot day. We removed all the bass in a can filled with their Maryland water (pH just about neutral) and during the road journey of about 1½ hours to the hatchery, we slowly changed to our own water (clear soft water from sandstone mountain streams, pH 6.6 to 6.8). We pumped through about 120 gallons of spare water without resorting to air, and the temperature went up 10 degrees on the journey. The fish were very thin but with good finnage, and barring two or three they all swam well down. As we were cooling off to 68 degrees at the hatchery before putting the bass in the quarantine furrow, a tabanid fly bit me on the arm and it got swotted into the fish can. Up came a smallmouth and took his first feed south of the Equator; and that evening the newspaper man got it that "the smallmouth bass were rising to the fly at Jonkershoek." A few minutes afterwards the smallmouth fingerlings were revelling in in their freedom in the sunshine, charging up and down the small shallow furrow, rubbing in the bright gravel and striking freely at small fry, Daphnia magna and insect larvae. There was no shyness about their table manners.

This was the first time on record that American game fish had been transported directly to South Africa. Rainbow trout ova and largemouth bass fingerlings came by way of England. Mr. A. M. Powell and the officials of the American-South African Line Inc. had made a bit of fishery history.

Until the end of November 1937 the smallmouth bass were kept in the small furrow under constant observation, and they fed well but made no appreciable growth in the confined space. Four weaklings died during the first few weeks, leaving 25.

We had a new dirt pond at the bottom of the hatchery, draining to waste. This small pond is 28 yards long by 6 yards wide and it contained goldfish fry and a host of frog tadpoles and water insects. We broke the quarantine in the case of one of the smallmouth fingerlings measuring 3¾ inches long, and put him alone in this pond on November 11. In fourteen days he was removed and was just 5 inches long and greatly increased in bulk. This fish was put in a large pond away from the others and

had grown to 9 inches long by the end of February 1938 and to 10 inches long by June 1938. It really was a male and we lost it by a most unlucky accident.

The remaining 24 smallmouth were held back in growth during the quarantine period, but they soon began to catch up when given greater range. Fifteen were put in a pond of 33 yards by 16 yards (.11 acre) which contained a rich supply of tadpoles, snails, freshwater crabs and insects, to which we added goldfish fry and top minnows (Gambusia holbrooki). They grew very shy, but I watched 14 basking at the surface on a hot day in January 1938 (mid-summer at the Cape) when they looked to average 6 inches long. By the first week in March 1938 they were seven to eight inches long. The other 9 smallmouth were purposely held back in small ponds after removal from the quarantine furrow, in case the Natal Provincial Administration wished to take them to Natal as breeders, but they just would grow. On February 24th 1938, six of them, by then about 6½ inches long, were put into trout carboys sent down from Natal for the purpose, and were put aboard the M. V. "City of New York" once more for transport to Durban. They all died during the first day of this voyage, we think from the effects of the soft Cape water on the unvarnished perforated zinc baskets in the Natal carboys, which are used successfully in Natal basic water.

In March 1938, a crystal clear beautifully weeded old pond of 45 yards by 20 yards (.185 acre) was set aside as a stock pond for the smallmouth remaining at Jonkershoek. When the rearing ponds were drained and netted on March 22, 1938, only 15 survivors could be found. They measured from 6½ inches to 8 inches long and were all put in this stock pond. At the end of May 1938 the fish were netted for examination just before the Cape winter, and the smallest was 7¼ inches long and the largest about 10 inches. They were in very high condition, and had not eaten out the available food as hundreds of top-minnows remained.

Early in June 1938, that smallest bass of 7¼ inches long was found floating dead. It was a female and the ovaries contained eggs in a state of development which gave promise that the remaining stock might be expected to spawn in the Cape spring months of September/October 1938. I sent Mr. Powell the ovaries in a tube. To some extent this knowledge compensated for the loss of this valuable fish. But with the original stock reduced by half, those winter months were a period of anxiety as the smallmouth continued to be very shy and only occasional swirls in the water could be seen to denote their presence. Hope was maintained that the effect of transportation from the northern to the southern hemisphere would be to promote precocity in the remaining stock, in spite of their rather small size as potential breeders. The period from May to October 1937, passed in Maryland represented one normal growing season in that climate, but from November 1937 to May 1938 these bass had experienced a prolonged additional growing period, followed by four months of very mild Cape winter when the water temperature was rarely below 50 degrees Fahr. and during which feeding was most probably maintained.

The smallmouth bass stock pond at Jonkershoek was ideal in section being excavated in the hill slope with the maximum of shallow shore line on the sides away from the levee. The water is quite clear and the supply can always be controlled. The bottom of the entire pond is soft, with weedy shallows or submerged lawns of

lakewort and no natural hard beds. On September 18, ten beds of coarse gravel were put down in various positions. Three beds were put into recesses cut out in the levee in 2½ to 3 feet of water and the other arranged along the other shores. We were too uncertain of spawning this year to feel justified to build permanent stalls. A few days later some of the gravel had been cleaned-up. On September 29, I flushed a small bass of about 7½ inches long from a bed in the sheltered corner of the levee. At the end of September, the water was sometimes under 60 degrees Fahr. at night, and we have never had largemouth bass breed at Jonkershoek until about the middle of October. On October 3, pigmented fry were found on the gravel of this corner bed and when a fry screen was put on, a few swam up into the bobinet cone. Some removed for closer observation in a glass tank were capable of swimming with the sac nearly absorbed, but they died that night when the water temperature fell to 56 degrees and all those in the screen disappeared. It is thus evident that the earliest spawning must have taken place soon after the gravel was put in on September 18, and that the smallmouth commenced to breed before they were seventeen months old.

On October 3, three other beds of eggs and newly-hatched fry were found. For fear of a cold snap, 500 were siphoned off and put in tanks in the hatching house, and 25% survived to the swimming stage. Another 422 were placed on clean gravel in a floating box of wire cloth in the pond, and on October 16, 103 swimming fry were counted out. The male fish continued to guard beds, but in several cases the eggs went bad and the beds were remade. The stock pond was rich in small native entomostracans although it had not been fertilized. On October 28, fry from the second-phase beds were removed from the screens to rearing furrows and fed Daphnia magna. The third laying phase occurred on October 15. Development of these eggs was watched in glass jars, and with water temperature of 63 to 65 degrees, they hatched in 4 days, and the fry were feeding on small slow-swimming crustacea by October 30. There has been no further sign of spawning by this small stock of young smallmouth breeders, and their efforts at the beginning of October were by far the most successful. We have thousands of fry from that nesting phase, the best at 45 days old being about 1½ inches long and very prettily marked.

The Government Trout Hatchery at Jonkershoek, near Stellenbosch, is located in the mountain valley of the Eerste River. It was laid out in 1894 and down to ten years ago its main production was eyed trout ova for "seeding" waters in Southern Africa. It is true that many hundreds of thousands of ova have been sent out for re-stocking (often waters quite unsuited for trout), but there has been no demand here for trout fingerling production on anything like the scale undertaken by even a minor American hatchery. It has really been a "seed" station and acclimatising center for our vast hinterland. For the last thirty years, the Curator, Mr. F. G. Chaplin, has evolved the place to suit the climatic conditions and to use his limited water supply from the mountain stream (falling in hot summer to a bare one-half cusec) to the best advantage. Working almost single handed he has made it not only a very practical trout hatchery, but a place of great beauty, an oasis and center of attraction for anglers and lovers of nature who visit the Cape. There he has acclimatised and bred brown and rainbow trout (Eastern brooks failed dismally!), European tench and perch. In 1928 largemouth black bass were brought out from England, propagated and distributed in small lots all over South Africa, so that now we must have hundreds of thousands of wild bred fish (I hesitate to write "millions" although I am

convinced that it runs to that). Of late years we have been developing the place as a pond fish station in addition to a trout hatchery, but the limited water supply has prevented the construction of large ponds. It is really only during the present bass season that we have got going with a good production of the Daphnia magna, which originated from Ohio ephippia kindly sent to me by Dr. T. H. Langlois in 1936. In our climate this cladoceran goes on continuously through the year and it is far more reliable and amenable to intensive production than our native species.

ARTIFICIAL SPAWNING AND PROPAGATION OF BLACK BASS IN WISCONSIN

By G. E. Sprecher, Asst. Supt. of Fisheries
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PROOF OF THE old adage "Eternal vigilance is the price of success" was well taken by the Wisconsin Conservation Department in its attempt to master the art of economically producing small and large mouth black bass on a large scale. The artificial spawning and rearing of large and small mouth bass is now an established practice in Wisconsin.

Pond culture has been the principle method of rearing black bass practiced by fish culturists in the United States for many years. This method involves the placing of a number of adult fish in a rearing pond and allowing them to spawn and hatch their eggs naturally. Various types of boxes containing gravel and other artificial structures were sometimes placed in the pond to aid the bass to find suitable spawning grounds. One serious obstacle to successful rearing of black bass by this method is the presence of the adult fish in the waters after the fry are hatched. If the ponds were well constructed with a flat clean bottom, the adults could be seined out. However, the seining process greatly disturbs the young fry and also the vegetation which provides them with shelter and natural food. If the adult fish are not removed, they soon become cannibalistic and feed on their own young.

Another practice which has been carried on by fish culturists is to seine fry out of lakes which are overstocked with the species. The young fish are thus removed when they have reached an age of from one to two weeks. At that period of their lives they live in schools and are easily picked up with a dip net. There are two principal objections to this method. First, the removal of young fish from their natural habitat to other waters disturbs their natural feeding and breaks

up the school of fish. As a result it is difficult for them to readjust themselves to a new home and most of them die in the attempt. Another serious objection to this method is the possibility of picking up other cannibalistic species of fish when seining for bass fry. A few strangers in the pond which have been overlooked by the fish culturist can consume most of the bass in the pond during the summer.

At a meeting of Wisconsin fish hatchery foremen held during the year 1934 at Madison, Conservation Director H. W. MacKenzie announced that Wisconsin must promptly develop an expanded panfish and bass propagation program including an extended effort in artificial propagation of these fish. Since 1934, the fisheries division has been exerting every effort to follow these orders and discover new methods of propagation which would be efficient and would result in increased production of these species. These efforts included the artificial spawning of small and large mouth black bass, bluegills, crappies, and rock bass.

Mr. MacKenzie's orders were rapidly carried out as far as bluegills, crappies, rock bass, and sunfish were concerned. Little difficulty was experienced in obtaining adult spawning fish. They were easily spawned and the eggs fertilized and after being placed in hatching jars soon hatched into strong healthy fry. A good percentage of bluegills, rock bass, and sunfish hatched from the green eggs obtained. From 51 to 87 percent of all eggs taken hatched out. Crappie eggs, however, showed a tendency to deteriorate in the jars. In 1937, we discovered that a large amount of slime from the bodies of the crappie dripped from the fish into the eggs during the spawning process. Spawners now wash their gloves after handling each fish and thereby eliminate this menace. As a result of this process, several state hatcheries this year reported a hatch of 87 percent of all crappie eggs taken.

The growth of Wisconsin's panfish propagation program from 1934 to 1937 is best illustrated by the increase in the numbers propagated and distributed to the waters of the state. Bluegills increased from 189,098 in 1934 to 23,401,250 in 1937. Crappies increased from 413,688 to 18,992,225 in the same period. Forty-seven rock bass were propagated in 1934 and 54,434 in 1937. Sunfish figures are similar showing 401,374 in 1934 and 4,437,032 in 1937. Of course, the major portions of these species are planted as fry. However, 85 to 95 percent of this increase is directly due to the artificial spawning of the aforementioned species.

This growth of our panfish program was indeed gratifying, but we realized that the important part of our job had not been done. That job was to artificially spawn and hatch small and large mouth black bass. It is true that our black bass program showed an increase of from 381,223 in 1934 to 1,935,850 in 1937. However, we realized that before a really large program could be carried out we would have to discover the secret of artificially spawning this species of fish.

In spite of the fact that the artificial spawning of black bass was believed impossible, Wisconsin fish culturists in 1937 tackled the problem with a "do or die" spirit. A small number of eggs was finally taken from both large and small mouth black bass without injury to the adult fish. First indications were that it would be impossible to take the spawn from a female bass unless she had first deposited a

few eggs naturally. In 1938, however, we discovered that a fish which was ripe for spawning could be spawned artificially without first having partially spent herself naturally. Our method is to gently massage the belly of the fish until the eggs begin to appear. After this point is reached, the eggs are easily removed from the fish. It is highly important that spawner attempt to remove the eggs only from fish which are definitely ripe. A one pint size glass dish should be used to receive the eggs.

Proper handling of the male fish is just as important as of the female. Males of both small and large mouth bass provide a very small quantity of milt. It is very essential that it be utilized to the greatest possible extent. To do this, we use a small glass to pour water over the vent of the male during the spawning operation. This washes the milt over the eggs and properly fertilizes them.

The foregoing process was used during the 1938 spawning season and, of course, may be improved upon in the future. Eggs were transported to the hatchery in a twelve-quart enamel pail half filled with water. Bass eggs have very little tendency to adhere together. Therefore, it is not necessary to use clay or other substances to prevent adhesion.

These "precious" eggs were placed in hatching jars and the same technique used as in hatching pike-perch eggs. The fry hatched in about five days and were placed in rearing tanks. Lacking knowledge of proper procedure resulted in a heavy mortality of fry. However, a wealth of knowledge to be used in our 1938 program was obtained. Proper spawning utensils, methods of transporting green eggs, methods of handling male and female fish, and especially the proper handling of fry after hatching, were our most important lessons.

One of the most important tasks connected with the work is to obtain a large number of fish at the time they are spawning and to return them to the water after stripping them without injury. In the 1938 spawning season, fyke nets were set in four lakes known to be productive of large mouth bass. All nets were set on the north and east sides of the lakes in about four feet of water. The water temperature was over 60 F. before the fish started spawning. Five hundred large mouth black bass were taken in our nets this year. Of this number, 128 were ripe. Fifty small mouth bass were found in our nets, of which 27 were ripe. Unripe fish were returned to the lake immediately. The ripe females weighed approximately two pounds each. The males averaged one pound each.

The eggs were then transported to the hatchery in twelve-quart enameled pails half-filled with water and after reaching the hatchery were tempered and placed in glass hatching jars. The water was then turned on and the eggs rolled for approximately 100 hours. After hatching, the fry remained in the jars for a few days until they started to forage and swim out of the jar. They were then transferred to rearing troughs. Natural food, including polyphemus and other species of water fleas and minnow fry, was fed to them and they were frequently sorted to prevent cannibalism.

Fifty thousand large mouth bass fry hatched in this manner were placed in rearing ponds to be reared to fingerling size. It required 102,040 eggs to produce this

number of large mouth bass fry. There were no adult bass or other fish present in the pond and the young fry had every opportunity to develop without molestation. Twenty thousand four hundred three-inch fingerlings were removed this fall and distributed to Wisconsin waters. In addition to the large mouth species, four thousand small mouth bass fry were placed in the same pond. Twenty-three hundred of these were distributed during September after they had reached a size suitable for planting.

To the casual observer, it would appear that artificial propagation of black bass is unnecessary. Nests of eggs guarded by adult male fish may be seen during the spring of the year in clear shallow water. The eggs appear to be clean and 100 percent fertile. The reason for this apparent high fertility is that the adult fish cleans the nest constantly and usually removes the infertile eggs early in the morning. Just how many of the original deposit of eggs are infertile is not known, but careful observation indicates that the final hatch is less than one-half of the eggs originally spawned in the nest. Also, since the nests are in shallow water, the eggs are subject to sudden and extreme changes of temperature. Not infrequently are all the eggs in a nest killed by variable climatic conditions. It, therefore, becomes our duty to improve nature's method in the same manner as has been done with pike-perch, muskellunge, trout, and many other species of game fish.

Our greatest problems in the propagation of artificially spawned black bass are concerned with water temperatures and feeding. It is believed, however, that experiments this year have shown how to overcome these difficulties and the propagation of these species will be a relatively simple matter in the future. The economies effected by artificially spawning both species of black bass are sufficient to make this work a very important part of Wisconsin's fish propagation program.

THE USE OF CHLORINE FOR DISINFECTING FISH PONDS

By H. S. Davis,
U. S. Bureau of Fisheries

OF ALL DISEASES that affect trout, furunculosis is the most feared. This is not due so much to the high mortality that usually accompanies an outbreak of furunculosis as to the fact that the nature of the disease is such that it is very difficult to combat and control. Furunculosis is essentially a septicaemia, the bacteria multiplying in the blood and consequently being carried to all parts of the body. Here and there the bacteria may leave the blood stream and start growing in the tissues,

causing their eventual disintegration with the formation of a characteristic bloody substance composed of broken down tissue and blood cells in which float enormous numbers of the causative bacteria.

It is obvious that chemical dips or medicines in the food will have little effect on the development of such an organism. So the fish culturist has no choice but to look helplessly on while his charges die. Unfortunately, before the presence of the disease can be easily recognized in individual fish the bacterial lesions are so far advanced that quantities of bacteria are being liberated in the water where they are free to infect other fish. But far worse than this is the well-known fact that fish which to all appearances are perfectly healthy may harbor the bacteria. Such "carriers" are no doubt frequently responsible for successive epidemics which follow each other from time to time.

So one can imagine the consternation that followed the discovery that furunculosis had appeared at the Bureau of Fisheries hatchery at York Pond, New Hampshire. This was a threat to the Bureau's fish cultural activities in a particularly vulnerable spot for the York Pond station is the principal source of its brook trout eggs. To make matters worse, the presence of furunculosis was not realized until the disease had been spread throughout the entire plant by the transfer of infected fish to various ponds for holding through the summer.

When an outbreak of furunculosis first appears at a hatchery there are two alternative courses of action. The course usually taken is to temporize and try to prevent the spread of the disease as far as possible. This may result in saving a few fish at the time but, at best, the course of the epidemic is only retarded temporarily. Eventually all susceptible trout become infected and the mortality at times may be very high. This is especially likely to occur during the spawning season, or at times when water temperatures are higher than usual. Where brood stock are held over from year to year, the disease becomes firmly established and probably never disappears entirely although the mortality is usually considerably less after the first few years.

The other course is to stamp out the disease before it becomes firmly established. This involves the destruction of all trout at the station and thorough disinfection of all ponds, raceways, buildings and equipment that might have become contaminated by the bacteria. Such measures may seem unnecessarily drastic but they are the only ones that can be relied upon to eradicate the disease.

Despite the fact that the York Pond station presented exceptional obstacles to the eradication of furunculosis, it was decided that this should be attempted. Without a personal knowledge of the station it is difficult for one to realize the magnitude of the task. The station occupies a considerable area in the White Mountain National Forest and is surrounded on all sides by second-growth timber. The brood fish are reared under as natural conditions as possible in eleven dirt ponds ranging from less than an acre to about two and one-half acres in area. Several of these ponds drain into York Pond, a natural pond about 21 acres in area. To add to the difficulties, several ponds contain stumps and logs in various stages of decay. This is especially true of York Pond, extensive areas along the shore being practically

covered with logs and brush. In addition to the ponds there are a large number of raceways, most of them with gravel bottom.

Two distinct watersheds are utilized for fish cultural purposes. Cold Brook provides the water supply for most of the raceways designed for fingerlings while the water for the brood ponds is carried by a large ditch from the West Branch of the Ammonoosuc River. The ponds and raceways on this watershed are placed at intervals over a distance of about 2½ miles, connected by the ditch and in one instance, for about one-half mile by a natural stream. The two watersheds unite shortly before leaving the station grounds. In short, the water system at York Pond presents about as difficult a problem for disinfection as could be imagined.

Since with such a complicated water system any attempt to describe in detail the procedure on each pond would confuse the reader, only general features of the methods employed will be discussed here. Liquid chlorine, which was available in tanks of convenient size, was the principal disinfectant employed although water-slaked lime was also used in some cases. Fortunately, large quantities of chlorine are manufactured in the neighboring town of Berlin and since a total of over 14,000 pounds was used on the ponds this was a matter of some importance.

Before applying the chlorine, the ponds were drained and allowed to dry out in the sun for several days. All fish that had been exposed to infection were buried with quicklime where there was no possibility of the bacteria being washed into the water supply later. Then, beginning at the upper end of each watershed, all ponds, ditches, raceways, and pipes were disinfected in turn. In this way all possible sources of infection were treated with chlorine before starting work on any part of the water system below. In every case the objective was to introduce chlorine into the water until there was at least 5 p.p.m. (parts per million) of free chlorine present. In many instances this minimum concentration of available chlorine was greatly exceeded. Five parts per million of free chlorine is several times the amount required to kill the causative bacteria of furunculosis within a few minutes, but in view of the possibility that the bacteria might be protected more or less by being buried in the mud or by lying in crevices it was thought best to adopt a minimum concentration that would be considerably in excess of that normally required.

The chlorine content of the water was determined by the orthotolidine method in a Hellige comparator. Comparators are now available that will permit direct readings of the chlorine content up to 250 p.p.m.

It was found that a uniform concentration of chlorine could best be obtained by introducing it into the water as the ponds were filled. A section of garden hose was attached to the valve on the chlorine tank and the free end placed in the supply line. If the water entered a pond through a pipe under pressure it was a simple matter to get the required amount of chlorine into solution. However, in the case of ponds supplied through an open ditch it was more difficult to get the necessary concentration. Under such conditions the chlorine is dissolved in the water as it rises to the surface in the form of gas bubbles from the end of the hose. Obviously the amount of gas dissolved can be increased by increasing the depth of the

water and by breaking up the gas into as fine bubbles as possible. The latter was accomplished by attaching to the hose several feet of gas pipe, closed at one end, in which had been drilled a series of small holes. It was impossible to prevent the escape of some chlorine from the water but after a little experience the loss was so reduced as to be insignificant. With the larger ponds that could not be filled in one day, it was necessary to introduce chlorine continuously day and night until the ponds were filled.

York Pond presented a special problem since it was impossible to drain it although the water surface was lowered several feet. Even when lowered as far as possible, the area of the pond was not greatly reduced and in many places the water was six to ten feet deep. To add to the difficulties, there was a considerable growth of pond weeds in parts of the lake and plankton organisms were abundant. Fortunately, it was possible to flow water into the pond at several points at each of which as much chlorine as possible was added to the water. Chlorine was also introduced directly into the pond from a small motorboat with a length of hose ending in a section of perforated pipe trailing from the stern. Heavily chlorinated water was run into the pond without interruption for three days and two nights during which time about 7,000 pounds of chlorine was used. Tests showed that a minimum concentration of 2 p.p.m. of available chlorine was present in all parts of the pond and in many places the concentration was much higher. All organisms in the pond, including fish, were apparently killed. Large numbers of dead trout, suckers and dace were observed and at the end of the treatment no evidence of live fish could be found, even in the most protected areas. Pondweeds (Potomegeton) were also killed. The shores, exposed by lowering the water level, were sprayed thoroughly with hydrated lime.

The fact should be emphasized that chlorination of the ponds at the York Pond station was essentially experimental. No one concerned had had previous experience in the use of chlorine in this manner and, as the work progressed, greater efficiency was obtained as the result of experience. There is no question that much larger amounts of chlorine were used in many cases than was necessary, and if the work was to be done over again it could be carried out much more efficiently and cheaply.

As a result of our experience it is believed that liquid chlorine has distinct possibilities for disinfection of hatchery ponds and equipment. It is comparatively cheap 1/, is easily applied, and has the great advantage over other chemicals used for this purpose that it disappears quickly from the water. If, for any reason, it is necessary to expose fish to chlorinated water before the chlorine has had time to disappear it can be immediately neutralized by adding a solution of sodium thiosulphate.

Many fish culturists have been reluctant to use liquid chlorine because of the danger in handling. In reality, however, there is very little danger if a few elementary precautions are rigidly adhered to. Chlorine can be purchased in iron cylinders containing 50 or 150 pounds of liquid chlorine. The liquid is under great

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1/ In most sections it can be purchased for 7¢ per pound delivered. In large quantities it is somewhat cheaper.

pressure and is converted into a gas as it escapes through the outlet valve. Naturally a very slight movement of the valve will greatly increase the amount of chlorine that escapes. As the chlorine expands, the temperature is lowered resulting in the formation of frost on the outside of the valve and the attached hose. The lowered temperature may cause the valve to "freeze" stopping the flow of chlorine temporarily. For that reason it is necessary to have someone always in attendance to open the valve slightly when it freezes and maintain a uniform flow of chlorine. Reducing valves are available, which can be attached directly to the tank and make it easier to maintain a uniform flow of the gas. The valves, however, are quite expensive and in our experience are not really necessary although their use would undoubtedly simplify matters and results in some saving of chlorine. The operator should have a gas mask for use in emergencies.

As previously pointed out, where small ponds or raceways, supplied with water through pipes are to be disinfected the procedure is very simple. The end of the hose with several feet of perforated pipe (iron or hard rubber) is inserted in the water main and the chlorine released as required. For best results the pipe should be full of water and the pond filled as rapidly as possible. If the water enters the pond through an open ditch some means must be provided for covering the end of the hose with at least three feet of water. Greater depths are desirable since it is evident that the greater the amount of water through which the chlorine bubbles must ascend, the greater the opportunity for the gas to go into solution.

When only small quantities of chlorine are required it will be better in most cases to use calcium hypochlorite, which liberates chlorine when dissolved in water. A high test calcium hypochlorite is available under the trade name of "HTH." The chlorine content of "HTH" is said to be quite uniform which enables one to determine, with certain limitations, the amount of "HTH" required to produce any desired concentration of chlorine.

Chlorine reacts with any organic matter that may be present in the water and for that reason more will be required to produce the desired concentration in ponds containing considerable quantities of organic material.

Another complication enters the picture when large ponds that require some time to fill are to be disinfected. When chlorine dissolves in water, part of it unites with water to form hypochlorous acid (HOCl) and a smaller amount of hydrochloric acid (HCl). The remainder is present as free chlorine. However, in direct sunlight the hypochlorous acid gradually decomposes into hydrochloric acid with the liberation of oxygen. As soon as the hypochlorous acid begins to decompose more chlorine unites with the water to form the acid and the process continues until all the chlorine disappears. For those chemically inclined the process may be represented as follows: $2HOCl = 2HCL + O2$. This may seem to be a complicated process and the only reason for referring to it here is to point out that when chlorination requires considerable time we must take into consideration a partial loss of chlorine through this means. This was well illustrated in our work on the larger ponds where early in the morning the water would show a chlorine content of several parts per million while tests made at the same place several hours later showed no free chlorine present. In the case of York Pond, water taken from the surface during the middle of the day showed no

free chlorine while at depths of four to six feet the chlorine content was 1-3 p.p.m.

In small ponds, which could be filled rapidly, this loss of chlorine was not an important factor and no difficulty was experienced in getting as high as 15-20 p.p.m. of chlorine in all parts of the pond, even during the hours of brightest sunshine. It is evident, however, that a considerable saving in the amount of chlorine required can be effected by treating ponds during cloudy weather or at night.

While it is believed that chlorine affords a comparatively inexpensive and efficient means of disinfecting hatchery ponds it is also evident that anyone without experience in its use should experiment on a small scale before attempting to use it extensively. Since the amount of chlorine required to obtain the proper concentration will vary widely under different conditions, it is not possible beforehand to determine accurately the amount that will be required in any specific case. The only reliable method is to test the water frequently to determine the amount of free chlorine actually present. Fortunately, the test is a very simple one. The addition of a solution of orthotolidine to water containing free chlorine produces a colored solution extending through different intensities of yellow to a deep reddish brown. Since the intensity of the color is proportional to the amount of chlorine present the amount can be determined accurately by comparison with a color chart. This is the principle utilized in the chlorine comparator. In the absence of a comparator a rough method is to add a few drops of orthotolidine solution to the water in a test tube or small bottle. A deep yellow or reddish brown indicates the presence of sufficient chlorine to kill bacteria in a few minutes. If the solution remains colorless there is no free chlorine present.

A COMPARISON OF THE GROWTH OF FINGERLING RAINBOW TROUT IN CONCRETE AND DIRT-BOTTOMED CIRCULAR POOLS OF THE SAME SIZE

By Eugene W. Surber
U. S. Bureau of Fisheries

THERE HAS BEEN controversy among Fish Culturists whether dirt or concrete-bottomed ponds or pools are best suited for rearing trout. The purpose of this experi-

ment was to determine whether the kind of bottom actually affects the growth.

On June 11, 1935, two lots of 9,000 fingerling Rainbow Trout, each, were counted and weighed before placing them in Circular Pool No. 5 with a dirt bottom and Circular Pool No. 6 with a concrete bottom. Both pools were 15 feet in diameter and received their water supply from the same main at a temperature of 54°. These fish were fed the same kind of diet, namely; sheep liver 60%; salmon egg meal 40%. Since the amount of food fed each lot is important, it was decided to feed each of these lots 4% of their body weight, which was obtained by weighing 1,000 fish at intervals of two weeks. The experiment was conducted with a fully stocked (9,000 fish), pool and conducted until the fish appeared to become crowded. Mortality records were carefully kept.

The extent of mortality in both lots was influenced by an outbreak of bacterial gill disease in both pools appearing in the dirt bottom pool No. 5 first on July 9th. These fish were dipped in a 1-2000 copper sulphate solution and transferred to pool No. 4, another dirt bottom pool of the same size. The presence of the bacteria was noted sufficiently early to avoid any considerable loss, only fifty-nine fish having died in the period of July 2nd to July 11th, inclusive, as shown in Table I.

Mortality in Concrete and Dirt-Bottomed Circular Pools
(Number of Individuals)

Period (All dates inclusive)	Pool with Concrete Bottom	Pool with Dirt Bottom
June 11 to June 21	15	12
June 22 to July 1	1	3
July 2 to July 11	16	59
July 12 to July 21	18	22
July 22 to July 31	391	35
August 1 to August 9	14	6
August 10 to August 19	4	5
August 20 to August 30	2	2
Total:	461 (5.12%)	144 (1.60%)

Bacterial gill disease made its appearance in the concrete bottom circular pool on July 23rd. The presence of the bacteria was not detected quite early enough to prevent a considerable loss and 391 fish died during the period July 22nd to July 31, with the greatest loss (179 fish), occurring the day after the fish were dipped. Since no other pools with concrete bottom of the same size were available these fish were dipped and placed in pool No. 14 on July 23rd, then returned to pool No. 6 on July 24th. The mortality record totals for these experimental pools show losses of 5.12 for the concrete bottom pool as compared to 1.60 for the dirt bottom pool. However, the time at which bacterial gill diseases was detected in each pool made the difference in the mortality figures and it should not be concluded that concrete-

bottomed pools are less healthy than dirt bottomed pools. The comparative growth of the two lots of fish is illustrated in Table II.

Growth of Fingerling Rainbow trcut in Circular Pools
(Individual Weight in Grams)

	6/11	6/25	7/9	7/23	8/2	8/15	8/30	% Increase
Dirt Bottom:	3.11	3.29	3.52	5.10	6.01	8.73	10.43	235
Concrete Bottom:	3.06	3.29	4.20	4.99	6.12	9.36	11.45	274

CONCLUSIONS

(1) No significant difference was found in the growth of fingerling rainbow trcut during an eighty day period in which a normal lot of trout were carried in circular pools of the same dimensions, one with a dirt bottom and the other with a concrete bottom.

(2) Although the actual mortality in the dirt bottcm pool was less than in the concrete pool the time of detection of the presence of gill bacteria unquesticnably made the difference in the mortality.

COMMENTS FROM OUR READERS

AN EXPERIMENT IN REARING SMALL-MOUTH BASS

EDITOR, THE PROGRESSIVE FISH CULTURIST:

The writer owns and operates a small hatchery where we specialize in small-mouth bass, our production being sold to conservation departments in different states and to private individuals.

Due to limited rearing facilities, we are unable to prcduce any large number of fingerling; therefore, practically all of our production is dispcsed of as fry. Successful shipments are made by railway express to all points in the United States. Since our rearing facilities are limited, any experiment along that line must of

necessity be confined to small pools. We are giving, herewith, results from one experiment with the yield high enough to warrant the interest of fish culturists.

On March 1, 1938, a small (10' by 40') pool, located below the dam of our main lake and fed with the flow through a small pipe from the main lake, was cultured with green cow manure (100 pounds) for daphnia, filled with water, and stocked with 300 local top-water minnows. Within two weeks, a good production of daphnia was noted, and this production continued for a period of ninety days. The top-water minnows were fed daily with a small amount of ground cereal. On April 13, minnows started spawning (70°) and by April 26, a good hatch of baby minnows was in evidence.

On April 28, 100 small-mouth bass fry, one week old, about one-half inch in length, were added to this rearing pool. Within ten days, a marked growth was noted in the baby bass, and from that time on one pound of ground mackerel was fed to this pool each day.

In spite of the fact that a wire fence had been erected around the pool to keep out bull frogs, a large tadpole hatch appeared and the tadpoles became so numerous that it was decided on June 7 to drain the pool and remove them. In this operation, we recovered the full 300 top-water minnow adults, but no baby minnows. We recovered 90 small-mouth fingerling, about 1½ inches long, this being a 90% yield in six weeks' time.

After removing the tadpoles, the pool was refilled with water and the original 300 top-water minnows and 83 out of the 90 fingerling bass were returned to the pool (7 of the 90 fingerling being killed in handling). We continued feeding one pound of ground mackerel daily. The bass continued to grow and appeared very healthy.

On July 25, during a three day rainy spell, the top-water minnows completely disappeared and on July 28, we drained the pool and recovered 81 fingerling small-mouth bass, measuring from 4" to 5" in length, not a single top-water minnow being recovered.

The pool varies in depth from nothing at one end to two feet at the other. The temperature of the water varied from 70° at the beginning to 90° at the end of the experiment.

This is the net yield of 81% out of 100 small-mouth fry, reared in a pool of 400 square feet, or the equivalent of eight to ten thousand fingerling per acre. This is the best yield of all the many experiments we have carried out and confirms my belief that the rearing of small-mouth fry into fingerling resolves itself into the factors of proper water conditions and temperature, food, and the separation from all other cannibalistic fish.

Jas. H. Reeve
Calhoun, Georgia

REVIEWS

LAKE MANAGEMENT REPORTS, HORSESHOE LAKE NEAR CAIRO, ILLINOIS

By Davis H. Thompson and George W. Bennett, Illinois Natural History Survey. - Biological Notes No. 8, Urbana, Illinois, September, 1938

This paper deals with a subject of perpetual interest to those concerned with the management of fresh water game fishes; the population level at which the largest yield of fish of the most desirable size can be maintained. The conclusions held by the authors on this subject are stated in the introduction. In studies of fish populations and fish production carried on for many years by the Illinois Natural History Survey it has been found that each type of water studied has the capacity to support a certain fixed number of pounds of fish per acre. This poundage may be composed of a large number of small fish or of a smaller number of larger fish; the total poundage nevertheless remains the same. If the total amount of fish flesh is disturbed by putting in or taking out fish, the level will be restored in a very short time. Even the removal of as much as one-fourth of the total amount of fish in a lake results, according to the authors, in no noticeable changes in abundance. From this they conclude that the yield of game fishes from an ordinary lake can be many times the amount taken out by ordinary fishing.

This conclusion is extremely interesting and, if adequately supported, significant. It would seem that proof of such a thesis would require data showing population changes under varying intensities of fishing. However, no evidence of this type is given, but the authors devote the balance of the paper to the effects of predation and competition among species as inferred from successive samplings of the fish population of a specific lake.

Horseshoe Lake, which is the subject of this study, is a 2400 acre body of water formed in its present state by the construction of a concrete dam in 1931. The lake is part of a former channel of the Mississippi which has grown up in cypress, gum, willow, and buck brush, although considerable areas of open water remain. The depth varies from one to six feet. Plantings of fish included stocks of small bass, crappies, bluegills, channel cat, bullheads, small carp, and buffalo brought from the Illinois River in December, 1931, and larger bass stocked in the early spring of

1932.

The fate of the fish populations of Horseshoe Lake has been checked in 1934, 1936, 1937, and 1938, in each of which years "a crew of men outfitted with boats, nets, and a miscellany of scientific equipment caught, identified, measured, weighed, and took scales from large numbers of fish. This information made it possible to estimate the abundance of the important species in the lake, their rates of reproduction, rates of growth, and death rates."

Within the limited scope of the present paper, the authors have not found opportunity to present the data which might explain the very interesting changes which took place in the population of the larger game fishes, the crappies and bass. However, the general course of events is related.

In the spring of 1932 the largemouth black bass spawned successfully. Predators were not numerous and a large number of the brood survived. The lake was still young and, as in many recently impounded waters, food was abundant. The bass, it is stated, responded to these favorable conditions more readily than any other species. They grew so rapidly that in a year they were almost twice as long and six times as heavy as the average yearling bass in the Mississippi Valley. However, increasing competition for food by crappies caused the growth rate to drop to normal in the second year, then below normal, finally almost to zero. Meanwhile, spawnings later than that of 1932 had been unsuccessful. Although young were produced nearly all disappeared and it is assumed they were eaten by crappies. Therefore the original 1932 brood still constitutes more than 90 percent of the bass population. Furthermore, although bass made up 4½ percent of all fish taken in the survey in 1934, in 1938 they accounted for less than one percent.

Like the bass, the black crappie produced a tremendous brood of young in the spring of 1932. This brood grew at a normal rate during its first two years. Thereafter, growth was retarded by dwindling food supplies and since 1936 these fish have not grown at all. Increasing competition from the white crappie is cited to explain the fact that moderate reductions in the 1932 brood from year to year have not resulted in increased growth of the survivors. According to the diagrams presented, no successful broods have been produced since 1932 (with the exception of a much smaller brood in 1935) but it is not stated whether this lack of incoming year classes is due to failure of spawning or to destruction of young by predators. The 1932 group therefore continues to dominate the black crappie population.

The white crappie, unlike the bass and the black crappie, produced a brood of only moderate size in 1932. It continued to produce small broods in successive years, and the young of this species escaped the presumable fate of the young bass and black crappie spawned in these later years. Therefore, while the proportion of bass (and supposedly of black crappie) in the surveys has declined progressively, the proportion of white crappie has steadily increased.

It is a little disappointing that only the most meager information is given about the white crappie, although its apparent success in competing with its neighbors and adapting itself to changing conditions makes it in a sense the most

interesting of the three species. We are not told, for example, how the growth rate of the white crappie was affected by conditions in the lake. In the discussion it is not always clear whether the white or the black crappie is referred to. Unfortunately, strictly parallel data for the three species are not given, so that it is impossible to make a satisfactory comparison of their fate.

The paper brings many unanswered questions to mind. Why, for example, did the white crappie escape destruction while every brood of bass and black crappie produced subsequent to 1932 was devoured by predators? Is the fact of predation established by food studies or might attacks of parasites, to which some species are more susceptible than others, be the explanation? Why were the bass better able to take advantage of the abundance of food in the newly created lake than the crappie, a more omnivorous fish? Why, especially in view of the "head start" gained by the bass in 1932, were these bass not able to give as good an account of themselves later as the smaller group of white crappie of the 1932 group?

Doubtless many of these points would be explained by a full presentation of the data. It is hoped that the authors will find an early opportunity to publish a complete account of the findings of these surveys.

It is an obvious conclusion that the lake is badly overstocked. To re-establish the bass in satisfactory numbers the authors recommend: (1) Relieving them from competition and predation by taking out more crappies, and (2) planting bass too large to be swallowed by crappies.

An interesting statement is the one that "reduction of the number of bass has resulted from competition and predation by the crappies, as well as from fishing. Hook and line fishing has apparently removed a larger percentage of the bass than of the crappies."

Considering this statement in the light of the author's central thesis that removal of fish by fishing does not seriously disturb the total population of a body of water, it is apparent that this generalization must be accepted, if at all, with reservations. Granted that the total poundage of all kinds of fish remains the same, it is evident that the balance between species may be materially changed. The factors of predation and competition among species complicate the picture, and in the case cited the removal of bass by fishing was not followed by a restoration of the bass population to its former level. Therefore we cannot be assured that the population of the most desirable species will remain at a fixed level.

Another statement that needs qualifying is this: "Fish grow to more desirable sizes and furnish a better quality of food and sport when their numbers are reduced enough to give rapid growth rates." This generalization could not be understood as applying to any one species, in the light of findings on predation and competition reported later in the paper.

R. L. Carson

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